1972

On representation in short-term memory: a developmental study

Saraswathi Subramanium
Iowa State University

INFORMATION TO USERS

This dissertation was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.

2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again — beginning below the first row and continuing on until complete.

4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.

University Microfilms

300 North Zeeb Road
Ann Arbor, Michigan 48106

A Xerox Education Company

On representation in short-term memory: A developmental study

by

Saraswathi Subramanium

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Majors: Child Development
Psychology

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Departments

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1972

TABLE OF CONTENTS

Introduction

It is rather surprising to find that most child psychologists have shown a marked lack of interest in most of the problems of memory that have been attracting the attention of so many other researchers in the past few years (Palermo, 1970, p. 218). To be sure, theorizing and experimenting on memory process has become a major interest and activity in psychology. However, much of the research has been conducted with college students as Ss. Palermo's observation may be construed as a plea for research on the development of memory processes. This could be a very fruitful area for significant contributions to the understanding of child behavior and development.

Research related to the developmental aspects of memory, is not entirely lacking, however. Atkinson, Hansen, and Bernbach (1964) have developed a method which is feasible with preschool children. In their study, eight picture cards were shown serially and placed face down in a row. The children were then shown a single test picture and asked to point to the face-down card that was the same as the test card. As expected, the proportion of correct responses at a given position was found to be a decreasing function of the number of items intervening between presentation of the items and its test for recall. Although these investigators did not present any statistical analyses, their data indicate that the rate of forgetting is very similar for both their 4 and 5 year old Ss. The importance of the Atkinson et al., (1964) study rests in the fact that their results indicated that the technique used

by them was successful in permitting the collection of orderly data from young Ss. A number of studies have since then utilized the technique or variations for securing developmental data (e.g. Hansen, 1965; Maccoby & Hagen, 1965; Bernbach, 1967; Hagen & Kingsley, 1968; Kingsley & Hagen, 1969; Bush & Cohen, 1970; Calfee, Hetherington & Waltzer, 1966; Calfee, 1970; and Keely, 1971).

Mnemonic mediation in children has been another area of active research interest. The recent surge of interest in this area can be evidenced in the works of Flavell and his associates (e.g. Flavell, Beach & Chinsky, 1966; Keeney, Cannizzo & Flavell, 1967; Corsini, Pick & Flavell, 1968; Moely, Olson, Halwes & Flavell, 1969; Daehler, Horowitz, Wynns & Flavell, 1969). Recent trends in research related to mediated memory in children has been reviewed by Flavell (1970) and also by Reese (1970), Paivio (1970) and Rohwer (1970).

There remains, however, a great dearth of information regarding most problems of concern pertaining to memory as a developmental phenomenon. The available evidence reviewed by Belmont and Butterfield, (1969) and Flavell (1970) indicate the numerous possibilities and the importance of developmental studies in this area. The main purpose of the present study was to investigate the developmental changes in short-term memory (STM), using the mode of presentation and type of interpolated activity as independent variables. Pertinent research and theory are reviewed in the following section prior to presenting the objectives of the present investigation.

Review of Literature

On Representation

One of the issues that has attracted much attention of the developmental psychologists in recent years has been concerning the ways in which a child's experiences with his world are encoded and stored. The cognitive developmental theories proposed by Piaget (1954) and Bruner (1966) have made a particularly significant impact in this direction.

Commenting on the developmental aspects of memory, Piaget (1968) says:

> "It is customary to represent memory as a system of coding and decoding, which naturally assumes the intervention of a code. But, curiously enough, this code itself has been studied very little, as if it were taken for granted that the code stays the same throughout development.... On the other hand, ...the most likely hypothesis is that the memory code...is modified during development, and depends at any given moment on the subject's operational level (1-2)."

While differences may exist in their formulations, both Piaget's and Bruner's theories recognize three modes of representation: action (sensory motor or enactive representation), image (ikonic representation), and symbol (symbolic representation). That these three media can be considered as important landmarks in development is brought out in Bruner's words:

> "At first the child's world is known to him principally by the habitual actions he uses for coping with it. In time there is added a technique of representation through imagery that is relatively free of action. Gradually, there is added a new and powerful method of translating action and image into language, providing still a third system of representation (Bruner, 1966, p. 1)."

Bruner particularly emphasizes that the three representational systems are parallel and each is unique, but also capable of partial translation, one into the other, accounting for the impulsion to cognitive growth.

Attempts to study the proposition of developmental changes in the mode of representation and its functional significance for learning and memory, have resulted in interesting, if somewhat contradictory findings. This is not surprising considering the complexity of the theory regarding the development of representation. There is no reference in the theory to an enactive stage or ikonic stage. Moreover, the theory does not maintain that enactive representation is replaced by ikonic representation; each kind of representation can be and is used at all ages after its inception.

The empirical base for the study of the development of representation comes from research related to the role of mnemonic mediation and imagery in children's memory and learning. Selected researches in the area have been reviewed by a number of leading workers in the field (Flavell, 1970; Reese, 1970; Paivio, 1970; and Rohwer, 1970). Vast differences in methodology, age of Ss and materials used in different studies makes comparisons difficult and of limited value. Some trends can be seen in the results of studies where comparison seems warranted. However, these trends do not seem to converge at this stage of limited knowledge.

Several studies on short-term memory for nonverbal material with young children have yielded the results indicating the facilitative effects of verbal labeling (e.g. Bernbach, 1967; Hagen & Kingsley, 1968;

Bush & Cohen, 1970). The Atkinson et al., (1964) procedure and the probe-recall technique was used in all three aforementioned studies. Kurtz and Hovland (1953) using the free-recall and recognition techniques had earlier shown that children who name objects at presentation show superior retention for the material relative to Ss who do not. The conventional explanation for this effect is that it reflects the superiority of words over nonverbal forms, as carriers of sense impression (Sperling, 1963). It should be mentioned here that in all these studies verbal labeling was experimentally induced and was not spontaneous.

While labeling appears to facilitate short-term memory in children at certain ages, the process does not seem to be a simple one. Several investigations have shown that verbal labeling has differential effects on the STM of children at different chronological ages. Hagen and Kingsley (1968) found that labeling did not affect performance of nursery school (4- and 5-year old) children, facilitated performance of 6- and 8-year old children, and did not affect performance of 10-year olds. The absence of an effect for older children was replicated and found to apply through age 14 and college age in the Hagen, Meacham, and Mesibov (1970) study.

Hagen et al., (1970) hypothesized that by age 10, children have developed strategies which consist of rehearsing the names of the items already exposed during the inter-trial intervals. Labeling disrupts these strategies by interfering with rehearsal. Additional support for the rehearsal hypothesis was derived from the finding that verbal labeling

of the stimuli resulted in a decrement for the primacy portion of the serial-position curve. Labeling facilitated recall for the most recently presented items at all age levels studied.

Supportive evidence for the developmental shift in the facilitative effects of labeling also comes from several studies using the free recall paradigm (Milgram & Furth, 1963; Horowitz, 1969; Kossuth, Carroll & Rogers, 1971). Labeling was observed to aid memory performance in younger children (Milgram & Furth, 1963; Horowitz, 1969) but not in older children (Milgram & Furth, 1963, Kossuth et al., 1971).

Evidence favoring the retention of pictorial material when compared with words, is presented in Corsini, Jacobus and Leonard (1969) study. The recognition memory of preschool children for picture and word pairs was tested. Their results, which contradict those of earlier studies by Ducharme and Fraisse (1965) and Dilley and Paivio (1968), is presented by Corsini et al., (1969) as evidence indicating that when proper response opportunities are available, the facilitative effects of pictorial encoding (for the young child) can be brought out more clearly. In both the Ducharme and Fraisse (1965) and Dilley and Paivio (1968) studies recall was verbal. In an earlier study by Corsini, Pick and Flavell (1968), it had been observed that spontaneous use of ikonic mediators was more common in their first grade Ss than among the kindergarteners. When specifically instructed to utilize ikonic mediators, however, children of both age groups were able to do so.

Ryan, Hegion and Flavell (1970) used preschool subjects aged 3 to 5 1/2 years to investigate the early beginnings of the ability to use

ikonic mediators. The data clearly showed that a number of preschool children were quite capable of spontaneously and deliberately utilizing pictures as ikonic symbols to mediate their recall, and this capacity was significantly age dependent across the 3-5 1/2 years age range.

In the studies reviewed in this section so far, only the Ryan et al., (1970) and Corsini et al., (1969) studies give a clue to the early appearance of ikonic mediation. Otherwise no clear developmental trend can be discerned leading one to conclude in a similar vein as Flavell (1970) that

> "As our studies have shown, even immature human Ss may variously engage in spontaneous verbal, ikonic and enactive forms of representational activity in their efforts to retain information (p. 194)".

A number of experiments pertaining to the issue of the role of imagery in children's learning, reviewed by Rohwer (1970a) however, presents evidence somewhat contrary to those reviewed above. Rohwer (1970a) summarizes his position on the issue of imagery in children's learning as follows

> "First it seems to me that...mental imagery is one of the processes whereby children represent and store information. It also seems to me, however, that a preference for and a capacity to make effective use of visual representation and storage develops later than is the case for verbal modes of representing and storing information (p. 401)".

This interpretation runs counter to the usual claim that ikonic representation develops earlier than symbolic (e.g. Bruner, 1966). Rohwer (1970a) provides the following

> "speculative rationalization for turning the usual developmental sequence on its head.... Language is a coherent, well-organized system, imagery is not. The capacity for

> utilizing well-organized systems is easier to acquire than the capacity for using more ad hoc means of controlling one's own behavior or of storing and representing information. Accordingly, the ability to use linguistic or verbal means for storing and preserving information emerges earlier developmentally than the ability to use visual or imagery processes for accomplishing the same ends (p. 401)".

All the studies reviewed by Rohwer utilize the paired associate task thus providing a methodological similarity for the direct comparison of the results. Earlier in this section, the Dilley and Paivio (1968) study had been cited as evidence that the preferred mode of storage for children is imagery. Their group of Ss (nursery school, kindergarten and first grade children) were superior in the recall of picture-word pairs than in any other combination of pictures and words. Rohwer (1970a) reinterprets the results of the Dilley and Paivio study as indicating support for his developmental prediction that the superiority of picture to word stimuli will increase with age. Supporting evidence is cited from the work of Rohwer and his associates (e.g. Rohwer, Levin & Suzuki, 1967; Rohwer, Lynch, Suzuki & Levin, 1967) leading to the interpretation that pictures evoke imagery at all levels assessed (nursery school to grade 6), but the ability to profit from the stored images is contingent upon the subject's ability to store an appropriate verbal representation of the object along with its image.

Reese (1970), a participant in a symposium on Imagery in Children's Learning, presents a critical evaluation of the finding that imagery facilitates paired-associate performance less than sentences in younger children but equally in older children. He examined six explanations namely, a). deficit in verbalization (images facilitate performance

only if described verbally; b). defective visual imagery (verbal material is remembered better than visual); c). production deficiency (verbal mediators are produced but not images); d). mediation deficiency (verbal and imaginal mediators are produced but only verbal mediate); e). leveling ("leveling" of the image of the stimulus-response interaction into separate images of the stimulus and response destroys the the stimulus-response association); f). failure to "read" (failure to observe the association depicted in the imagery condition).

While Reese (1970) himself favors the last of the six aforementioned explanations, the studies by Flavell and his associates cited earlier do suggest the existence of production deficiency in young children. Of course there is no indication in the data as to whether young children are more deficient in producing visual mediators than they are in producing verbal mediators or vice versa.

The data examined so far leaves one with two diametrically opposed views on the developmental nature of representation. Among the prominent workers in this area, Flavell (1970) and Reese (1970) seem to work within the framework of Bruner's assumption that cognition in young children is ikonic. Rohwer (1970a) on the other hand, from his reinterpretation of data on paired-associate learning, empnasizes the primacy of the verbal over the ikonic mode of representation. Cooper and Gaeth (1967) and Klein, Hale, Miller and Stevenson (1967) present evidence that there is no inherently preferred modality at different ages, adding yet another viewpoint to this complex issue! Only further research taking into account the nature of the stimulus material, the facilitation for

mediation (verbal or visual) and instructions to Ss over a wide age range can resolve the issue. Careful examination of the differences between production and mediational deficiencies as suggested by Flavell and his associates may also prove helpful in scrutinizing the problem. One can only speculate at this point.

Another way of exploring the possibility of developmental changes in the way items are stored in memory can be with the use of different types of interpolated tasks between presentation of items and recall. Empirical evidence regarding the effects of interpolated tasks on children's memory is sparse.

Maccoby and Hagen (1965) and Newell (1968) have reported on the effects of acoustic disruption on the short-term memory of children. Developmental data on the effect of interference comes from the Koppennal, Krull and Katz (1964) study. The performance of their eight year old subjects was quite comparable to the performance of college students in that considerable interference was exhibited in all measures of recall. However, the five year old children did not exhibit proactive interference and the four year old children exhibited neither proactive nor retroactive interference. None of these differences was obtained, however, in experienced subjects, who had had previous laboratory experience with paired associate learning.

The results of Gibson and Yonas (1966) study of the effects of visual and auditory interference on a visual scanning task, are of particular interest here. They report that a highly confusable visual context significantly reduced scanning rate for both children (grade 3) and

adults (college sophomores), but a highly confusable auditory context, played over earphones, had no effect on either group. There was a significant interaction with interfering visual context. All the variance in this interaction was contributed by the condition of high visual confusability, which reduced rate of scan relatively more for the children than for the adults. These experiments provide good examples of the type of questions that can be answered by research employing children as subjects.

The role of interference in short-term retention has been an active area of investigation, using adult subjects primarily. Some of the pertinent data are reviewed in the next section, prior to presenting the goals of the present research.

Role of Interference in Short-term Retention

In his 1957 Presidential address Underwood commented "I know of no one who seriously maintains that interference among tasks is of no consequence in the production of forgetting (p. 49)." A wealth of research findings have accumulated in this area during the past decade, and a number of specific variables affecting the nature of interference studied (e.g. Bruning & Schappe, 1965; Posner & Rossman, 1965; Posner & Konick, 1966; Wickelgren, 1966a, b; Conrad, 1964). While the amount of information reduction required is indicated to be the most significant variable affecting the forgetting rate, interference from other tasks also appears to be closely tied to similarity in both verbal and visual

tasks.

Sperling (1963) postulated separate visual and auditory short-term stores, based on the finding of superiority of auditory short-term memory when compared to visual (e.g. Broadbent, 1956; Murray, 1965) and on work using visual material (Averbach & Corriel, 1961; Averbach, 1963). On this modality-specific storage interpolated visual material could only enter and overload the visual store, and interpolated auditory material the auditory store. Margrain (1967) presents supportive evidence, since in his study interpolated activity of one kind damaged the retention of earlier material of that kind, more than material of the alternate type. This occurred for both visual and auditory retention. An explanation for inter-modality interference is suggested by Mackworth (1963, 1964). Mackworth suggests that the total amount of attention is limited and that some is diverted during the presentation of interpolated material away from the critical store.

For motor responses, equivalent losses in retention over time have been found whether the retention interval was unfilled or filled with activities which were primarily nonmotor (e.g. Posner, 1967; Posner & Konick, 1966a,b; William, Beaver, Spence, & Rundell, 1969). Since available motor STM data offered little evidence of interference effects, Adams (1967) favored a decay theory to explain the short-term forgetting of motor items. Posner (1967) concluded that kinesthetic STM codes have different central processing requirements than visual and verbal items, thereby indicating problems in the development of a general theory of STM.

Results of Pepper and Herman's (1970) experiments, however, have provided evidence of interference effects in motor STM. Analyzing their data in conjunction with some analyses made from Posner's (1967) and William's et al., (1969) data, they found that interference effects may occur both as a function of interpolated 'mental' activities not specifically related to the criterion motor act and as a function of interpolated, task related motor acts. Based on this analyses, Pepper and Herman, propose a two-process theory of motor STM incorporating both decay and interference effects. The theory has some resemblance to the two-process 'acid-bath' theory combining decay and interference features proposed by Posner & Konick (1966) and Posner (1967), for verbal and visual STM.

According to the 'acid-bath' theory, when opportunity for rehearsal is reduced, the rate at which the precision of information is lost is a function of the number and similarity of items which have been stored within an as yet unspecified temporal period of the trace which is to be recalled. In addition the original trace undergoes a weakening as a function of time alone. The evidence and analyses indicating that both decay and interference mechanisms operate in verbal, visual and motor STM provide some encouragement for postulating a common memory system.

The review presented in this section indicates the possibility of of a task specific representation and interference effects of adult subjects, supporting Bruner's (1966) thesis that the three modes of representation--enactive, ikonic and symbolic-- are parallel and unique. Due to the absence of developmental data on this issue, one

can only speculate regarding age differences in the interaction, if any, between the mode of presentation and nature of interference tasks.

Objectives of the Present Investigation

The Review of Literature presented here suggests the possibility of a developmental study of STM using different modes of presentation and interference tasks.

The overall aim of the present investigation is to study the developmental changes in short-term memory. This includes a). investigations of the effect of three different modes of presentation of stimuli (motor, visual, and verbal) on the STM of children at three age levels (grades K, 3, and 6); b). investigations of the effect of three types of interference tasks (motor, visual, and verbal) on each of the three modes of presentation for the three age groups; and c). investigations of interactions, if any, between mode of presentation and interference tasks and the age of the subjects.

Theory and available empirical evidence suggest that there may be developmental differences in the facilitative effects of modality on STM performance. It follows from Bruner's thesis on the development of representation that the youngest children (5-6 years in this study) should perform better in the motor task, the grade 3 children (8-9 years old) should perform better on the visual task and the grade 6 children should perform better on the verbal task, than the other two tasks.

Available information also indicates that there may be developmental

differences in the effect of different types of interpolated tasks on the STM of children. In line with Bruner's (1966) theory, it is hypothesized that motor interference should be most detrimental to the STM of young children (5-6 years), visual interference should be most detrimental in the case of 8-9 year olds and verbal interference should be most detrimental in the case of older children (11-12 years). The interference task presented in the same mode (motor, visual or verbal) as the memory task, should result in lower memory performance in all age groups. This hypothesis follows from a). the empirical data indicating the possibility of a task specific representation and interference effects in adult subjects (Bruning & Schappe, 1965; Posner & Konick, 1966a; Cohen & Granström, 1968; William et al., 1969) and b). Bruner's (1966) contention that the three modes of representation== enactive, ikonic and symbolic--are parallel and unique.

As in most developmental memory studies, there will probably be a significant increase in STM capacity with increasing age as revealed in memory performance. Empirical bases for this hypothesis comes from most studies using children of more than one age group (e.g. Hansen, 1965; Maccoby & Hagen, 1965; Keely, 1971). Theoretical support for this hypothesis can be derived from the exponents of the cognitive-developmental school of thought (Langer, 1969; Flavell & Wohlwill, 1969) emphasizing both qualitative and quantitative change.

Method

Pilot Study

A pilot study was undertaken using, as closely as possible, the probe recall method used by Atkinson et al., (1964). The Ss were 36 children enrolled in the Gilbert Community Schools, Gilbert, Iowa, in grades K, 3 and 6. The results revealed only a main effect of age. None of the effects of sex, mode of presentation, or mode of interference approached significance. The memory task proved to be extremely difficult; a third of the Ss did not perform above a chance level. The method and results of the study will not be described in detail because the results were not informative. Because of the results, however, the method and stimulus materials were modified considerably in the subsequent studies.

The following modifications were made in the conduct of the main study: a). The memory set per trial was reduced from eight to five. (An exploratory investigation with five serial positions using the verbal and visual mode and eight 6th grade boys as Ss indicated that this did not make the task too easy for them. The average correct response was 70 percent.) b). The reduction of the number of items per trial, helped to reduce the total number of trials from 32 to 20. Each serial position was tested four times, twice with interpolated activity and twice with no interpolated activity. c). The problem of distraction under unfilled delay conditions was difficult to tackle.

Hence it was decided to obtain immediate recall scores for 10 of the 20 trials, and a delayed recall with interpolated activity for the other 10 trials, even though this resulted in the confounding of delay with interference. d). The stimulus material for the verbal and visual conditions were changed from animal pictures and words to abstract pictures and words, since it was thought that this would bring out more clearly the age differences, if any, in the preferred mode of representation on memory. e). Passive viewing of the animal pictures for the visual distractor task had been observed to be ineffective as many children stared blankly at them and continued to rehearse the memory items. In order to make the S participate more actively in the interpolated activity, drawings were mounted on a big sheet and S asked to locate the ones called for by E.

Study I

Subjects

Fifty-four Ss participated in this study, 18 from each of the three grades--K, 3 and 6. All the children were enrolled in David Edwards Elementary School, Ames, Iowa. With the exception of one Mexican boy who was fluent in English, all the Ss were white Caucasian. There were equal numbers of boys and girls at each grade level. The mean age of the Ss at each grade level was--K: Boys, 5 years, 8 months; girls, 5 years, 7 months; Grade 3: Boys, 8 years, 11 months; girls, 8 years, 6 months; Grade 6: Boys, 11 years, 11 months; girls, 11 years

8 months. Three boys and three girls at each grade level were randomly assigned to one of the three experimental groups. Three of the initially selected Ss from Grade K had to be replaced by three others because of lack of sustained attention or lack of interest in participation.

Design

With three modes of stimulus presentation (verbal, visual, and motor), and three types of interpolated activities (verbal, visual, and motor), there were nine treatment combinations. For practical reasons it was decided to limit the number of experimental sessions per child to three. Since the within-subjects interactions were of particular interest in this study, a partially balanced incomplete block design was used, resulting in three experimental groups at each age level. The three groups were tested on the following modality-interference combinations: Group I: Motor-visual, motor-motor, and visual-visual; Group II: Visual-motor, visual-verbal, and verbal-motor; Group III: Motor-verbal, verbal-visual and verbal-verbal. The design of the study is presented in Table 1.

TABLE 1

Experimental Design: Study I

Mode of interference	Mode of stimulus presentation		
	Verbal	Visual	Motor
Verbal	Group 3	Group 2	Group 3
Visual	Group 3	Group 1	Group 1
Motor	Group 2	Group 2	Group 1

There were three boys and three girls at each grade level in each experimental group. The order of presentation of treatments within the experimental groups was counterbalanced.

Stimulus Materials

In order to make the stimulus materials for the verbal and visual modes of presentation clearly distinct, abstract words and abstract line drawings were used in Study I. Animal names and animal pictures had been used in the pilot study.

The abstract words were: Life, Truth, Hope, Cost, Time, Length, Idea, and Trouble. Out of these, a subset of five words was chosen randomly for each of the 20 trials. The words were chosen from a list of 16 abstract nouns used by Paivio and Yuille (1966). All the words have a Thorndike-Lodge (1944) AA rating and are reported as low in imagery and high in meaningfulness across the elementary grade levels (Paivio & Yuille, 1966).

Eight black and white line drawings of abstract figures comprised the memory set for the visual mode. The drawings were mounted on 5 x 3 1/2 inch cardboard pieces. Six of these difficult-to-label stimuli had been used by Kingsley and Hagen (1969) with preschool children. A subset of five randomly chosen drawings was used for each trial.

For the motor mode, eight geometrical designs cut out on a 9 x 3 x .12 inch cardboard pieces were used. These could be mounted vertically on a wooden block with a groove in the center. As in the verbal and visual mode, a subset of five designs, randomly selected,

was used for each trial.

The materials for the interpolated activities consisted of: a). A list of words acoustically similar to those included in the memory set (verbal interference); b). a set of the line drawings, visually similar to but not included in the memory set (visual interference); c). a geometrical design cut out on 12 x 4 x .12 inch cardboard piece (motor interference).

Procedure

Each subject was tested individually in three experimental sessions. Each session consisted of two practice and 20 experimental trials of a specified mode. The presentation time was approximately 20 minutes. For 10 of the 20 trials, the presentation of the memory set was followed by immediate probe recall test. For the remaining 10 trials, a specified interference activity was introduced for eight secs. between presentation and recall. The trials with and without interpolated activity were randomized in order of presentation. Each serial position was tested four times every session.

The general procedure for all three modes of presentation was kept as similar as possible. Five blank cards were placed in a row in front of S for the verbal and motor conditions, so that S's response always consisted of pointing to the card in the correct position. Order of presentation was from S's left to right.

Specific Procedures

Visual mode of presentation. The procedure used for the visual mode of presentation was essentially a replication of Atkinson et al., (1964) procedure. The memory set consisted of eight abstract line drawings. On each trial, a subset of five cards were randomly selected and these shown one at a time at a 3-sec. rate. After each card was shown to S, it was placed face down on the table, so that after all five cards were presented, they formed a horizontal row in front of S. For trials with immediate recall, a cue card identical to one of the cards presented on that trial was then placed face-up on the table and S asked to indicate the card that would match the cue card. For trials with interpolated activity, an interference in a specified mode was introduced between presentation of the memory items and the cue card. When incorrect in the first choice, S was asked to make a second choice after which, if necessary, the correct card was shown by E.

Verbal mode of presentation. The procedure was similar to that used in the visual mode of presentation, except that five abstract words were read aloud by E. A row of five blank cards (5 x 3 1/2 inch) was placed in front of S and E pointed to one card at a time while reading out the words. The cue word was spoken by E and S asked to indicate the card in the row with which the word was associated.

Motor mode of presentation. As in the verbal mode, a row of five blank cards was placed in front of S. The memory task consisted of associating a specific motor movement with a card in each of the five positions. One geometrical design at a time was mounted on a wooden

block and S asked to trace it with a pencil. As S finished tracing each design E pointed to the blank card with which it was to be associated. The cue card was one of the geometrical designs presented during a given trial. The E mounted the design on the wooden block and asked S to trace it. S was then asked to indicate the card with which the design was associated (see Appendix A for detailed instructions to Ss).

Scoring

Every correct first and second choice response was given a score of '2' and '1' respectively.

Study II

Subjects

Twelve children, two boys and two girls from each of the three grade levels (K, 3 and 6) participated in Study II. Of the twelve, six children (one boy and one girl from each age group) had participated in Study I and were chosen on the basis of high performance and motivation (Group I). The other six children participated only in Study II (Group II). All Ss were enrolled at David Edwards Elementary School, Ames, Iowa. With the exception of one boy from Hawaii who was fluent in English, all Ss were white Caucasian. The mean age of the Ss at each grade level was--Grade K: 6 years; Grade 3: 8 years, 7 months; Grade 6: 11 years, 6 months.

Design

A complete within-Ss design was used. Each child was tested on all the 3 x 3, Modality x Interference combinations. For Group I Ss who had participated in Study I and for whom data was available on three treatment combinations, data on the remaining treatments was collected in four additional sessions. For Group II, data was collected in 6 sessions, one session per day.

Procedure

The stimulus materials used and the procedure were identical to those used in Study I.

Results and Discussion

Age Differences in Memory Performance

There was a significant increase in memory performance with increasing age in both studies (Study I: $F(2,36) = 53.38$, $p < .001$; Study II: $F(2,6) = 42.36$, $p < .001$). The mean recall for both studies are presented in Table 2. Comparisons among these means using the

TABLE 2

Age Differences in Mean Recall Scores

	Age (Grade)		
	5-6 (K)	8-9 (Gr.3)	11-12 (Gr. 6)
Study I	8.29	11.28	14.81
Study II	9.65	10.60	16.06

Newman-Keuls procedure (Snedecor & Cochran, 1967, p. 273) indicated that the children in the sixth grade performed significantly better than children in the two lower grades. The difference between recall scores of K and third graders, was significant in Study I but not in Study II. (The complete analysis of variance of recall scores for Study I and II are included in Appendix B).

The differences in performance among the age groups is not surprising in that it has been documented in many other studies (e.g. Atkinson et al.,

1964; Hansen, 1965; Neufeldt, 1966).

Developmental studies using many different types of materials, and methods of presentation, have generally agreed in showing that STM increases over a wide age range. Atkinson et al., (1964) found that 5-year-olds scored a higher proportion of correct first-choice responses over all serial positions than did 4-year-olds. The ten year old Ss in Hansen (1965) study made more correct choices at all retention intervals than their 5-year-old Ss. Neufeldt (1966) found a significant age main effect, which resulted from the better overall performance of the 13-year-old Ss when compared to the 8-year-olds in a dichotic listening task. Supportive evidence also comes from Belmont (1967, 1969) using Ss from 8 years to adulthood. Improved performance with age was observed in both the perceptual STM (Belmont, 1967) and verbal STM tasks (Belmont, 1969).

Maccoby and Hagen (1965) using the Atkinson et al., (1964) type of procedure found that the recall of task-relevant material increased regularly with age. Their Ss came from the first, third, fifth and seventh grades. An increase in correct recognitions from kindergarten to fifth grade has been observed by Flavell, Beach and Chinsky (1966). More recently Keely (1971) has reported significant improvement with age on all four STM tasks used in her study. In her study, a visual STM task with easy- or hard-to-label displays and with or without repetition of stimuli over trials was used with 4-,8-, and 14-year-old Ss.

While the design of the present investigation does not permit

analyses of whether the observed age differences are due to differences in memory storage capacity or due to differences in strategies used for acquisition and retrieval, the latter possibility cannot be overlooked. Observations by Maccoby (1969) and Kagan and Kogan (1970) serve to emphasize this point. Discussing the problem of the young child's deficit in stimulus selection, Maccoby (1969) comments:

> "...it seems to me that it is not especially useful to think of the deficit in terms of the child's having a more limited "information processing capacity" or "memory storage capacity" in the usual meaning of these terms. Rather, the problem would seem to be that the "capacity" the young child has is not efficiently employed.... It is the effect of the unwanted material on the perception of the wanted material that is the heart of the problem (p. 88)."

Summarizing the factors contributing to individual variation in memory as a cognitive process, Kagan and Kogan (1970) conclude:

> "One of the perplexing problems is the fact that it is still not clear whether, or to what degree, recall failure is the result of imperfect registration, deficient rehearsal, or the effect of interference on the recall processes (p. 1304)."

The two observations succinctly emphasize that age differences in memory performance cannot be simply construed as due to increasing storage capacity with age. Absence of selective attention, deficient rehearsal, and susceptibility to distractions (external and internal) were observed more frequently among the younger Ss than the older ones in the present investigation. Similar observations have been made by other investigators using the same procedure (e.g. Donaldson & Strang, 1969; Ellis & Munger, 1966; Bush & Cohen, 1970).

The results of a study by Friedrich (1971) are also pertinent

here. He used eight-word stimulus lists which were free recalled. Half of the lists contained words with high-frequency associates and the other half (control) lists did not. Serial position effects for the 7-, 10-, and 14-year old Ss showed identical performance at late serial positions (5-8) for both types of lists. Some theories (e.g. Atkinson & Shiffrin, 1968) hypothesize that recently presented items are retrieved from a STM and that earlier items are retrieved from a more permanent, long-term memory. In the Friedrich study, early serial position recall increased with age and interacted with list type. Friedrich concluded that older Ss more efficiently encode information in long-term memory by using mnemonic encoding strategies. That is, while all groups performed better at earlier serial positions with associated words, the older Ss showed the maximum increase in performance with associated words (as compared with control words). Thus Friedrich's analysis suggests that the "capacity" of memory is a function of the ability to encode information efficiently--not a limit on the amount of "space".

Mediational deficiency (see Reese, 1962; 1970; and Flavell, 1970, for detailed discussion of this topic) has been discussed as another possible contributing cause of the young child's deficit in memory performance. Improved memory performance with the availability and use of ikonic and verbal mediators has been indicated in a number of studies cited in the Review of Literature (e.g. Bernbach, 1967; Hagen & Kingsley, 1968; Corsini et al., 1969; Bush & Cohen, 1970; Ryan et al., 1970).

Sex Differences in Memory Performance

No significant sex difference in memory performance was observed in either Study I or Study II ($F < 1.0$). Nor did sex interact significantly with the other independent variables namely, Age, Mode and Interference.

Interference Effects

The over-all significance of interference effect was observed in both Study I and II. (Study I: $F(1,36) = 52.85$, $p < .001$; Study II: $F(3,18) = 9.03$, $p < .01$). Thus interpolated activity between presentation and recall significantly lowered memory performance. It must be remembered that delay was confounded with interference in the present investigation. Comparisons among the means (Newman-Keuls) in Study II indicate significant differences between all possible comparisons and that the visual interference caused maximum forgetting. Motor interference had the least interfering effect. A similar trend was observed in Study I also. The interaction between age and interference effects was not significant (see Appendix B).

The absence of statistically significant interaction between age and interference is of particular interest here as it corroborates the existing evidence on the relation of forgetting rate to development. Although this investigation was not specifically designed to study age differences in forgetting rate as such, some observations regarding the same appear relevant here.

As Belmont and Butterfield (1969) have pointed out, evidence from studies testing STM over two or more retention intervals show no reason to believe that forgetting rate is related to development. Related evidence comes from studies using either an unfilled interval or intervals filled with some interpolated activity between item presentation and test. In the present investigation the retention interval was filled by any one of the three rehearsal preventing activities (motor, visual or verbal).

Atkinson et al., (1964) found marked forgetting, with correct choices decreasing fairly linearly as retention interval increased. The slope of the forgetting curve for both their 4 and 5 year old Ss appeared nearly identical. Hansen (1965) compared the forgetting rates of 5- and 10-year-olds, at two rates of item presentation, and found steep forgetting curves. Ten-year-old Ss made more correct choices at all retention intervals, indicating greater acquisition retrieval ability, but there was no difference in the slope of the forgetting curve between the fifth and tenth years. Maccoby and Hagen (1965) tested children from grades 1, 3, 5 and 7 for recall of task-relevant material with or without distraction. Distraction had a clear effect upon the acquisition of task-relevant information, lowering the scores at all age levels. There was, again, no interaction between age and distraction effect.

Belmont (1967) studied the development of perceptual STM by examining the delayed brightness judgments of 8-, 10-, 12- and 20-year-old Ss. There was marked forgetting, as shown by the relation of percent of "brighter" judgments to retention interval, but the slope of

the curve did not differ among the various age groups. Belmont (1969) examined verbal STM of Ss from 8 years to adulthood, using four retention intervals. Again, significant forgetting curves were observed, but the slope of these curves did not differentiate the age groupings. The similarity of the forgetting curves across age groups was even more clearly brought out by the finding that preventing rehearsal during the retention interval (by interpolated activites) significantly and equally decreased recall in all groups.

Although it is risky to infer from negative findings, evidence from the present investigation and those cited above seem to converge, indicating absence of developmental differences in the rate of forgetting.

Presentation Mode Effects (a)

The mode main effect and the interaction of mode with age failed to reach statistical significance in both Study I and Study II (see Appendix B).

It had been mentioned earlier in the Review of Literature that the data on the developmental primacy of any mode is quite chaotic at present with evidence to date leading to two diametrically opposed views. The negative finding in the present investigation, therefore, is not surprising. At least two attempts to test the proposition of developmental changes in modality preference have shown that there is no inherently preferred modality at any given age (Klein et al., 1967, Cooper & Gaeth 1967). A recall paired-associate paradigm was employed in both these studies. Children from grades 3 and 5 were Ss in the

former study and from grades 4, 5, 6, 10 and 12 in the latter.

Most of the evidence on this controversial issue of change in modality preference with age, comes from the work of Rohwer and his associates (see Rohwer, 1970a, b, for detailed discussion). Rohwer's main hypothesis is that the degree to which the visual mode is dominant over the verbal increases with age. Experimental support for this hypothesis are drawn by Rohwer (1970a) from his own data and from his reinterpretation of Dilley and Paivio (1968) data, showing that the superiority of pictorial items over verbal items increases with age. This interpretation runs counter to Bruner's (1966) view that the ikonic modes of representation have a developmental priority over the verbal modes of representation. Rohwer (1970a) suggests that language is a coherent system which is easier to use. Hence, it follows that the verbal mode of representing and storing information has developmental primacy.

Paivio (1970) has suggested that the age trends observed for the difference between word and picture materials reflect a developmental shift in decoding facility rather than in storage modes. A somewhat similar position was held by Corsini et al., (1969) who suggested that the apparent increases in the superiority of the visual mode are an artifact of the practice of requiring subjects to respond verbally when tested for recall of pair members presented as pictures. Using a recognition paired-associate paradigm, Corsini et al., (1969) found that preschool children showed better recognition memory for pictures than for words. They concluded that:

> "...young children are better able to encode pictorial input but have difficulty when the task requires them to translate their ikonic representation into a verbal response. Thus even though the young child may be better able to encode pictorial information, pictorial information will facilitate performance only when certain response opportunities are available, but will hinder performance, when other responses are called for (p. 193)."

The position held by Paivio (1970) and Corsini et al., (1969) regarding the superiority of the visual mode, however, differs in that Paivio suggests that the visual mode of representation is predominant at all ages, whereas Corsini et al., (1969) working primarily with preschool Ss suggest that the visual mode has developmental primacy.

In the present investigation, while the analysis of the combined scores (immediate recall score + recall score with interpolated activity) fails to reveal the dominance of any one mode, an examination of the means for immediate recall alone for visual and verbal modes does suggest some trends. The means for the immediate recall scores, verbal and visual, for the three age groups are presented in Table 3.

TABLE 3

Mean Immediate Recall Scores for Visual and Verbal Modes of Presentation

Grade	Study I		Study II	
	Modality		Modality	
	Visual	Verbal	Visual	Verbal
K	8.42	10.90	7.00	13.25
3	11.17	14.91	11.25	13.50
6	15.25	15.80	15.75	18.25

For the mean values presented in Table 3, in Study I the data for the visual and verbal modes of presentation came from different Ss while in Study II this was a within-subject variable. The data (Table 3) indicate that at all three grade levels the scores on the verbal mode are consistently higher. When the two extreme grade levels (K and 6) are compared, the difference between the visual and verbal mode for the kindergarteners appears to be greater than it is for the 6th grade children. With the data available from the present investigation, except for indicating such a trend, no definite conclusions are possible.

Since abstract pictures and abstract words (low imagery) were used as stimulus material, it is quite possible that with their superior verbal facility, the 6th graders easily labeled the abstract pictures thus making the two modes equivalent for all purposes. In fact, the post experimental interview suggests just such a possibility. Most of the 6th grade children reported giving specific labels to the pictures and using "mental elaborations" such as forming sentences with the given labels. Only three of the kindergarteners (from Studies I and II) reported attempts at labeling and even then not for all the pictures used.

It is not possible to determine whether the results obtained in the present investigation are due to the representational abilities of Ss, or the differences in the stimulus properties present in the different modes, or due to some other yet unidentified factor. As Rohwer (1970b) indicates

"The major issues still in need of attention include the

> theoretical problem of finding a unifying account of the effects of visual and verbal elaboration as well as that of clarifying the matter of visual and verbal dominance relations when viewed developmentally (p. 245)."

The motor mode is not chosen for comparative purposes here because it was observed that being confounded with visual exposure to stimulus, it ceased to be a motor stimulus for coding purposes. With this additivity of cues, the performance on the motor task at all grade levels, exceeded that of the visual, but was inferior to the verbal task.

Presentation Mode Effects (b)

There was a significant interaction between mode of presentation and interference in Study I ($F(2,72) = 5.80$, $p < .01$). In Study II, the interaction was marginally significant ($F(6,36) = 2.55$, $p < .05$). The observed interactions are illustrated in Figs. 1 and 2. In general, it appears that the interference tasks did not differentially interfere with retention of information presented in different modes. The results show that the verbal mode of presentation suffered interference effect whereas the other two presentation modes did not. Summing over groups in Study I, the mean recall for unfilled and filled intervals for each of the presentation modes was 12.5 and 12.5 for visual, 11.2 and 10.2 for motor and 13.4 and 9.2 for verbal. The differences between these means indicate that performance with filled interval did not affect performance under visual presentation and decreased recall in the other two. The largest reduction in recall occurred with the verbal mode of presentation.

In Study I, ANOVA for the three experimental groups (see Appendix C) show that the modality x interference interaction is highly significant only for Group 3 ($F(2,24) = 14.72$, p .001). This group was presented the memory stimuli in the verbal mode in two of their three sessions and in the motor mode in the third session. Fig. 1 shows that the verbal mode of presentation was interfered with by interpolated activity (of any kind) to a greater extent than the other modes of presentation. In Study II (Fig. 2) the difference between unfilled and filled conditions was ordered as in Study I; verbal showed the most interference, visual the least.

The observed interactions contradict the earlier observations (e.g., Posner & Konick, 1966) of modality specific interference effects. Whether this is due to the differential difficulty of the stimuli used in the present investigation for the three modes of presentation, for the three interference tasks, or both, it is hard to tell.

However, it might be that Ss had more information in the visual and motor modes than in the verbal mode. In both the visual and motor modes, the S was presented a visual stimulus which could have been implicitly named or mediated in some way. In effect, then, these modes were essentially bi- or multi-modal, yielding a greater number of attributes for encoding in memory. The verbal mode, offering but auditory information (and the blank, i.e., undifferentiated) cards, had a lesser amount of information to encode. The consequence was that a filled delay might have interfered to a greater extent with the memory trace for these stimuli. In the other presentation modalities, the filled delay might

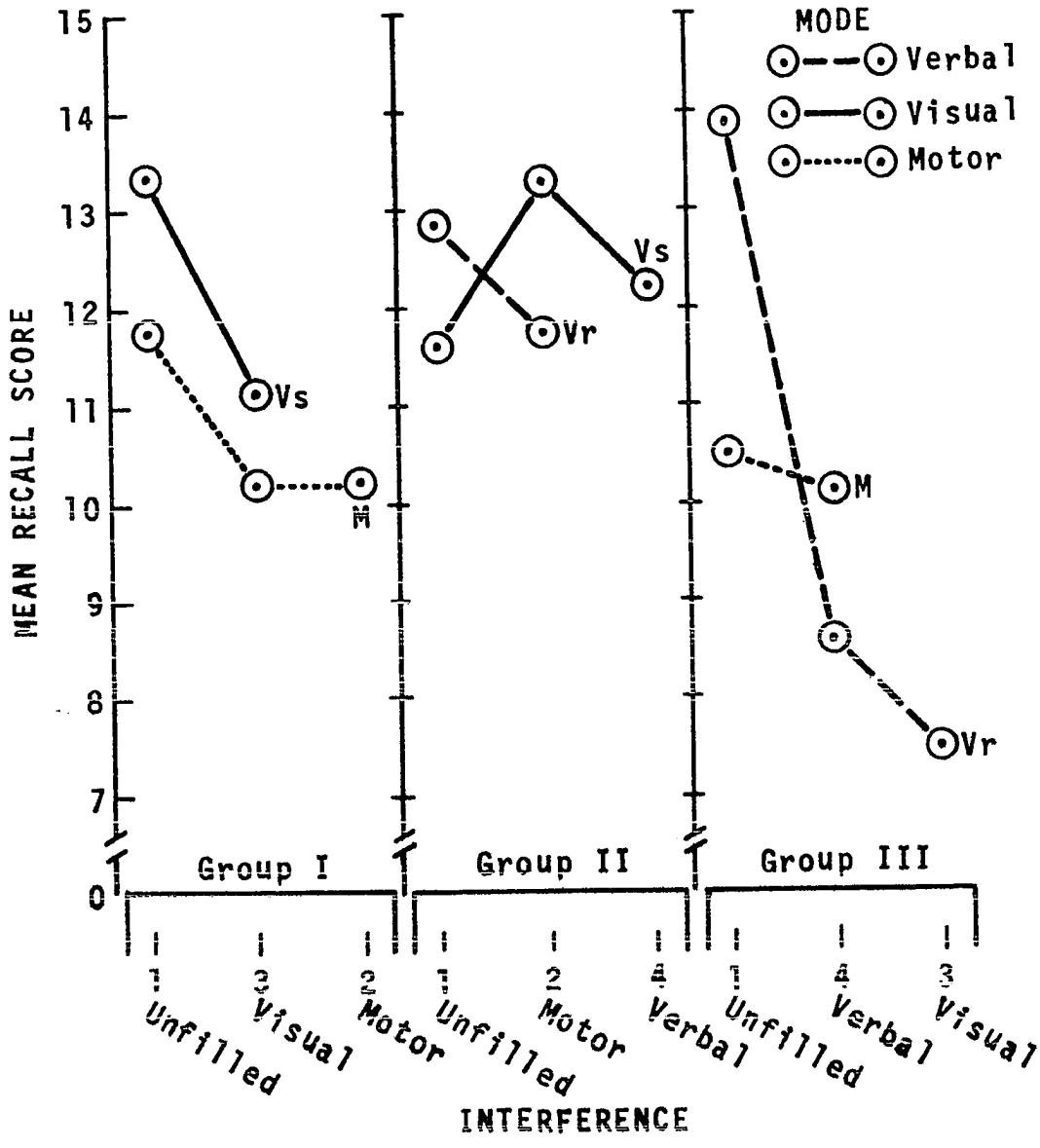

Fig. 1 Mean recall scores in Study I for three modes of presentation with immediate recall and three interference conditions

have had a lesser effect because the memory trace was multi-dimensional, i.e., based on more than one modality dimension.

The differences in the effects of interference among the groups also suggest "context effects." That is, Group III which had two-thirds of

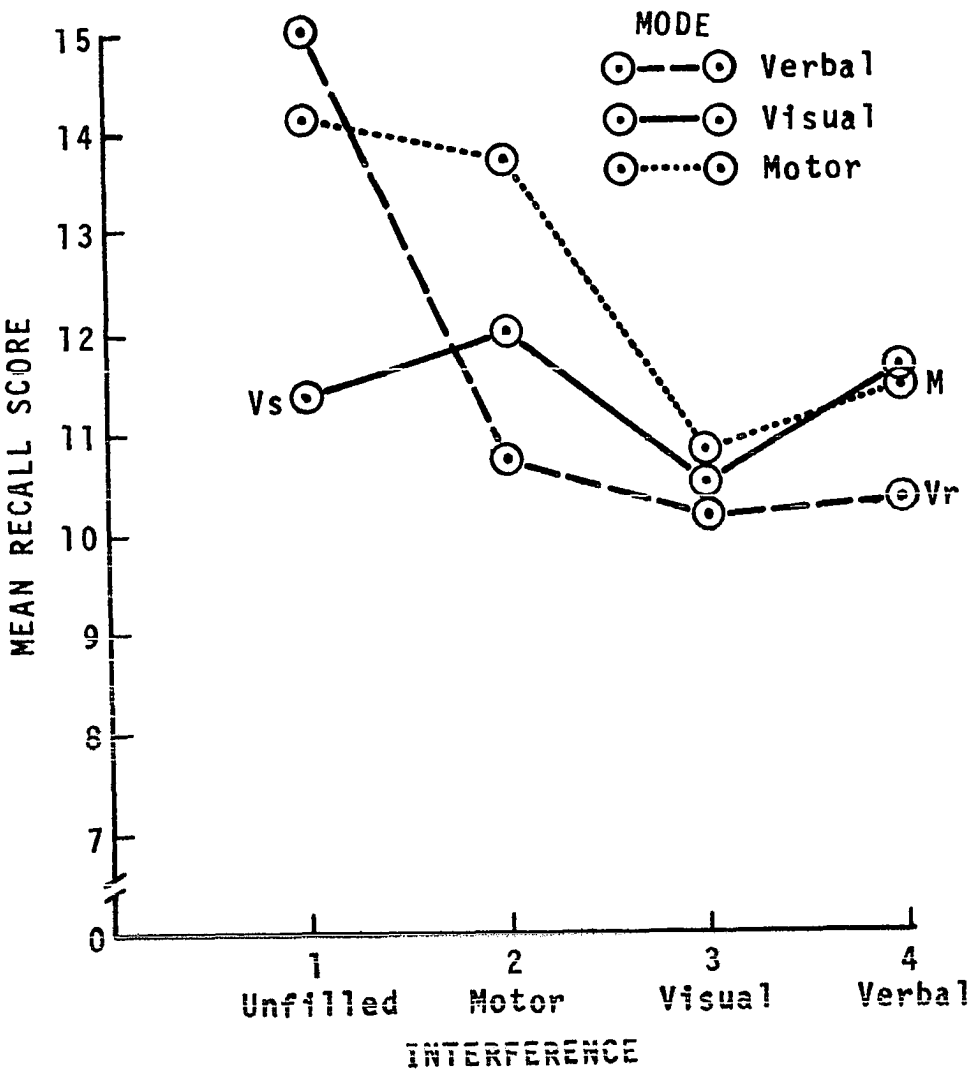

Fig. 2. Mean recall scores in Study II for three modes of presentation with immediate recall and three interference conditions

the stimuli presented auditorily showed greater interference effects than the Ss in Group II on the verbal modality. Whatever encoding strategy the Ss learned in dealing with the visual stimuli may have transferred to the remembering of the verbal stimuli.

Descriptive Analyses

Response bias. Several investigators (e.g. Murdock, 1966a, 1968; Donaldson & Strang, 1969; Calfee, 1970; and Keely, 1971) have pointed

out that a priori probabilities for correct response do not take into account response strategy. For example, the a priori probability of a correct response for any one position can be increased when Ss select it more often when uncertain. The bias for selecting the middle cards when uncertain has been observed to be a guessing strategy with young Ss (e.g. Donaldson & Strang, 1969; Calfee, 1970; Keely, 1971).

Using a corrected measure of performance defined as "the proportion of all choices of n which are correct choices", Donaldson and Strang (1969) reanalyzed Atkinson et al., (1964) data and also presented their own to show that a primacy effect was present in the performance of all age groups. Similar conclusions have been drawn by Calfee (1970) using the a posteriori probability and by Keely (1971) using the d' measure borrowed from signal detection theory (see Murdock, 1966a).

The a priori and a posteriori probability of correct response at each serial position in Study II of the present investigation are presented in Tables 4 and 5. Only the data from Study II were selected for this analysis, because data on all three modalities of presentations had been obtained from the same Ss.

The following observations can be made from the examination of the a priori and a posteriori serial functions: a) Corrected for response bias, the a posteriori serial functions presented in Table 5 appear quite orderly. b) Except for the visual modality in Grade 3 where there seems to be a marked absence of recency, all the data have the bowed shape characteristic of data from adults. The marked presence of primacy effect for both the younger age groups (Grades K and 3) in

TABLE 4

A Priori Probability of a Correct Response for Immediate Recall (Study II)[a]

Age group and modality	Correct position 1	2	3	4	5[b]
Grade 6: Verbal	75[c]	100	63	88	100
Grade 6: Visual	100	88	88	38	75
Grade 6: Motor	100	75	50	75	88
Grade 3: Verbal	25	25	63	75	100
Grad 3: Visual	25	75	75	38	13
Grade 3: Motor	63	63	38	50	75
Grade K: Verbal	38	0	50	75	100
Grade K: Visual	38	13	13	38	38
Grade K: Motor	50	25	63	38	75

[a] Data from Study II (within Ss design).
[b] Serial position 5 is the most recent item presented in all cases.
[c] Decimals omitted.

all modalities of presentation is of particular importance here. The data presented here is consistent with Keely's (1971) observation that while the primacy effect increases with age, it is not absent even at the youngest age level studied (4 years in Keely's study; 5 1/2 years in the present investigation). c). The absence of primacy effects in at least some of the a priori probability functions presented in Table 4 can be attributed to the guessing strategy of young children.

TABLE 5

A Posteriori Probability of a Correct Response for Immediate Recall (Study II)

Age group and modality	Correct position 1	2	3	4	5
Grade 6: Verbal	100	73	83	78	100
Grade 6: Visual	89	70	78	75	75
Grade 6: Motor	100	60	56	75	100
Grade 3: Verbal	100	40	42	54	100
Grade 3: Visual	66	46	40	50	33
Grade 3: Motor	83	38	50	50	86
Grade K: Verbal	38	0	57	46	90
Grade K: Visual	33	14	14	25	60
Grade K: Motor	57	29	41	100	86

d). In all three grade levels sampled here, the primacy and recency functions are less prominent in the case of visual STM than in the case of verbal- or motor-STM. The difference is more obvious in the recency function than it is in the primacy effect.

The absence of recency in the recall of items presented in the visual mode (in contrast to those presented in the auditory mode) has been observed by several investigators with adult Ss (e.g. Corballis, 1966; Murdock, 1966b; Conrad & Hull, 1968; Craik, 1969; Grant &

McCormack, 1969; Murdock & Walker, 1969). Modality effects on serial position curves has become an active area of research interest (see Morton, 1970 for detailed discussion).

Second choices. According to the all-or-none retention model, if S errs in the first choice, the second choice would be a random one selected from the remaining alternatives. The observed probabilities of correct second choice responses in Study II are presented in Table 6.

TABLE 6

Observed Probabilities of Correct Second Choice

Study II

	Modality of presentation		
Grade	Motor	Visual	Verbal
K	.56	.29	.52
3	.62	.41	.55
6	.95	.23	.88

The chance prediction was .25 for all three modes of stimulus presentation. As can be seen from Table 6, the Ss second choices in all three grade levels, especially for the motor and verbal mode, are correct more often than predicted by chance (.25). The sixth graders made comparatively very few errors in their first choice. When they did err, their choice was near the correct position and their second choice for the motor and verbal mode had a high probability of being correct; .95

and .88 in Study II.

Individual differences. As in other areas of psychological functioning, individual differences in memorial processes are inevitable. However, research related to identifying and describing the determinants of individual differences in children has hardly begun. An attempt is made in this section to describe some of the factors to which the observed variation in the present investigation may be attributed.

The description is limited to data from Study II only, as this provides information on both 'interindividual' and 'intraindividual' differences. The descriptive analyses are based on the observed variation in the recall scores (Table 7) and on the observations recorded by E and her assistant during the conduct of the experiment.

The availability and use of verbal 'labels' to encode memory items had been discussed earlier in this chapter as one of the possible factors accounting for age differences in memory performance. This is perhaps seen most clearly in the data presented in Table 7. There is a greater discrepancy between the recall scores of the sixth graders and kindergarteners in the visual than in the verbal mode. All the sixth graders in this Study (II) reported labeling the visual items while none of the kindergarteners did. It was also observed that for the verbal mode children at all three grade levels showed signs of active rehearsal whereas, only the sixth graders were observed to rehearse for the visual items.

Capacity for selective attention appears to be another crucial factor. While the four kindergarten Ss in Study II turned out to be

TABLE 7

Immediate Recall Scores for Verbal, Visual and Motor Items (Study II)

Grade/child no:			Mode		
			Verbal	Visual	Motor
6	1		18	16	18
	2		19	11	14
	3		17	19	19
	4		19	17	19
		$\bar{X}$ =	18.25	15.75	17.50
3	1		13	11	16
	2		14	10	11
	3		15	12	10
	4		12	12	16
		$\bar{X}$ =	13.50	11.25	13.25
K	1		12	8	17
	2		13	4	9
	3		15	7	13
	4		13	9	7
		$\bar{X}$ =	13.25	7.00	11.50

the most attentive (when compared with their counterparts in Study I), their capacity for selective attention was still inferior to that of the older children. Except for one boy who was very quiet, the other grade K children could hardly wait for each trial to be over before they could come out with comments like 'why haven't they painted the walls?' or 'where do you live?' indicating divided attention. This was quite a contrast to the older children who in their own words were "determined not to miss any!"

Attention appears to be influenced by motivation and so does memory performance. The sixth graders were more upset by errors (as indicated in their comments 'oh no!', 'maybe you tricked me' 'next time I won't miss it') than were the grade K Ss who were quite happy that they came so close to the right answer.

Finally, a note on some intraindividual differences. There appear to be individual differences in modality preference. This is most clearly seen for example in the distribution of scores of child 2, grade 6 and child 1, grade K (see Table 7). The kindergartener had commented that the motor task was 'most fun' of all the three tasks. He had also been observed to make exaggerated movements while tracing the geometrical design thus providing himself with additional 'motor' information.

General Discussion

Sidman (1960) makes an interesting point that when an experiment is performed to test no hypothesis there can be no negative results. Gollin (1965) adds that

> "the broader, less confining attitudes accompanying curiosity-inspired research may convert 'errors' 'inadequate' subjects and 'faulty' apparatus into promising leads for new directions of research (p. 184)."

With optimism derived from the above observations, some limitations of the present investigation are examined and directions for further research suggested.

Choice of the memory task. Contrary to Atkinson et al., (1964) who claim that their Ss (3 1/2 - 5 1/2 years age range) 'showed no signs of fatigue or lagging interest' over the 32 trials, the pilot study did reveal that the grade K Ss (5-6 years) could not sustain their interest over that many number of trials. Even with the reduction of number of trials to 20, at least some of the kindergarteners did show fatigue by the end of the 20 min. session. While it cannot be refuted that this method does provide orderly data and can be introduced as a game to the young Ss, a technique need be devised whereby information can be collected in not more than 15 min. sessions. A paired-associate recall or recognition paradigm may provide the same data in lesser time.

Complexity of the interference task. While an attempt had been made in the present investigation to make the interference tasks presented in the different modes to be of equal difficulty, it was observed that the Ss' involvement differed. The Ss' role was more passive in the

verbal interpolated activity than in the visual. This may partly account for the poorer memory performance with visual than with verbal interference. In further investigations care need be taken to see that the Ss participation is the same in all interference activities.

Choice of Ss of appropriate age groups. The choice of Ss of ages appropriate for the study of a given developmental phenomenon appears to be an irksome problem in most developmental research. In the present investigation selection of Ss of preschool age instead of kindergarteners may have yielded more information regarding the enactive mode of representation. Associated with this is the problem of selecting a task that is not too difficult for the youngest Ss and yet not too easy for the oldest Ss studied. Otherwise there arises the problem of ceiling and floor effects in performance. Research with children of a wider age range may answer some of the questions not answered by the present investigation.

Sampling 'bias'. This is another one of the ever present problems in research in behavioral sciences. The sample in the present investigation cannot be considered representative of even white middle class American children. The Ss came from a school in an upper middle-class locality and were mostly children of college professors. A more representative sample of children may yield developmental information different from that of the present Ss coming from a highly verbal environment.

Concluding comments. The findings of the present study, most specifically the absence of a Mode x Age interaction raises doubts

regarding the applicability of Bruner's thesis regarding developmental changes in the preferred mode of representation to the age-span studied here (5 to 12 years). With the ever increasing bombardment of verbal stimuli through the media of television, and the increasing accessibility to the printed material in books, the shift to verbal encoding of stimuli is likely to occur earlier now than ever before. A study similar to the present one using Ss from 2 to 8 years of age may provide developmental information that could not be obtained in the present study.

The major issue here remains the failure of the present experiment to detect developmental differences in the relative efficiency of verbal, pictorial and kinesthetic modes of representation. At least three features of the present study make it impossible to give a definite answer to the question of whether or not any one of the modes has developmental priority. a). The performance of the youngest population sampled here was only slightly above chance level and it is likely that this obscured the differences in the effects of the interpolated activities. b). The second age group in this study consisted of a sample of third-graders. It is quite possible that by this age compensatory processes may have already developed to the point where they obscure the primacy of any one mode. c). The motor task was confounded by visual exposure to the stimuli, resulting in Ss remembering them as "what they looked like". This lack of distinction between the motor and visual mode may again have obscured the developmental differences, if any, in modality preference.

Literature Cited

Adams, J. A. Human Memory. New York: McGraw-Hill, 1967.

Atkinson, R. C., Hansen, D. N., & Bernbach, H. A. Short-term memory with young children. Psychonomic Science, 1964, 1, 255-256.

Atkinson, R. C., & Shiffrin, R. M. Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), The psychology of learning and motivation: Advances in research and theory. Vol 2. New York: Academic Press, 1968.

Averbach, E. The span of apprehension as a function of exposure duration. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 60-64.

Averbach, E., & Corriell, A. S. Short-term memory in vision. Bell System Technical Journal, 1961, 40, 309-328.

Belmont, J. M. Perceptual short-term memory in children, retardates and adults. Journal of Experimental Child Psychology, 1967, 5 114-122.

Belmont, J. M. Short-term memory. In J. M. Belmont (Chm.), Perspectives in research on retarded learning. Symposium presented at the annual convention of the American Association of Mental Deficiency, Denver, May, 1967. Cited by J. M. Belmont and E. C. Butterfield, Relations of short-term memory to age and I.Q.. In L. P. Lipsitt and H. W. Reese (Eds.), Advances in Child Development and Behavior, Vol. 4. New York: Academic Press, 1969.

Belmont, J. M., & Butterfield, E. C. The relations of short-term memory to development and intelligence. In L. P. Lipsitt & H. W. Reese (Eds.), Advances in Child Development and Behavior, Vol. 4. New York: Academic Press, 1969.

Bernbach, H. A. The effect of labels on short-term memory for colors with nursery school children. Psychonomic Science, 1967, 7, 149-150.

Broadbent, D. E. Successive responses to simultaneous stimuli. Quarterly Journal of Experimental Psychology, 1956, 8, 145-152.

Bruner, J. On cognitive growth. In J. Bruner, R. Olver, P. Greenfield, et al. (Eds.), Studies in Cognitive Growth. New York: John Wiley, 1966.

Bruning, J. L. & Schappe, R. H. Type of interpolated activity and short-term memory. Psychological Reports, 1965, 16, 925-929.

Bush, E. S. & Cohen, L. B. The effects of relevant and irrelevant labels on STM in nursery school children. Psychonomic Science, 1970, 18, 228-229.

Calfee, R. C. Short-term recognition memory in children. Child Development, 1970, 41, 145-161.

Calfee, R. C., Hetherington, M. E., & Waltzer, P. Short-term memory in children as a function of display size. Psychonomic Science, 1966, 4, 153-154.

Cohen, L. B. & Granström, K. Interpolated task and mode of recall as variables in STM for visual figures. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 653-658.

Conrad, R. Acoustic confusions in immediate memory. British Journal of Psychology, 1964, 55, 75-84.

Conrad, R., & Hull, A. J. Input modality and the serial position curve in short-term memory. Psychonomic Science, 1968, 10, 135-136.

Cooper, J. C., & Gaeth, J. H. Interactions of modality with age and with meaningfulness in verbal learning. Journal of Educational Psychology, 1967, 58, 41-44.

Corballis, M. C. Rehearsal and decay in immediate recall of visually and aurally presented items. Canadian Journal of Psychology, 1966, 20, 43-51.

Corsini, D. A., Pick, A. D., & Flavell, J. H. Production of nonverbal mediators in young children. Child Development, 1968, 39, 53-58.

Corsini, D. A., Jacobus, K. A., & Leonard, S. D. Recognition memory of preschool children for pictures and words. Psychonomic Science, 1969, 16, 192-193.

Craik, F. I. M. Modality effects in short-term storage. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 658-664.

Daehler, M. W., Horowitz, A. B., Wynns, F. C., & Flavell, J. H. Verbal and nonverbal rehearsal in children's recall. Child Development, 1969, 40, 443-452.

Dilley, M. G., & Paivio, A. Pictures and words as stimulus and response items in paired associate learning in young children. Journal of Experimental Child Psychology, 1968, 6, 231-240.

Donaldson, M., & Strang, H. Primacy effect in short-term memory in young children. Psychonomic Science, 1969, 16, 59-60.

Ducharme, R., & Fraisse, P. Etude génétique de la memorisation de mots et d'images. Canadian Journal of Psychology, 1965, 19, 253-261. (English Abstract).

Ellis, N. R., & Munger, M. Short-term memory in normal children and mental retardates. Psychonomic Science, 1966, 6, 381-382.

Flavell, J. H. Developmental studies in mediated memory. In H. W. Reese, & L. P. Lipsitt (Eds.), Advances in Child Development and Behavior. Vol. 5. New York: Academic Press, 1970.

Flavell, J. H., Beach, D. R., & Chinsky, J. M. Spontaneous verbal rehearsal in a memory task as a function of age. Child Development, 1966, 37, 283-299.

Flavell, J. H., & Wohlwill, J. F. Formal and functional aspects of cognitive development. In D. Elkind, & J. H. Flavell (Eds.), Studies in cognitive development: Essays in honor of Jean Piaget. New York: Oxford University Press, 1969.

Friedrich, D. D. Developmental analysis of short-term memory capacity and information encoding strategy. (Doctoral dissertation, Iowa State University) Ames, Iowa: University Microfilms, 1971. No. 71-21,943.

Gibson, E. J., & Yonas, A. A developmental study of the effects of visual and auditory interference on a visual scanning task. Psychonomic Science, 1966, 5, 163-164.

Gollin, E. S. Developmental approach to learning and cognition. In L. P. Lipsitt & C. C. Spiker (Eds.), Advances in Child Development and Behavior, Vol. 2. New York: Academic Press, 1965.

Grant, K. W., & McCormack, P. D. Auditory and visual short-term memory with successive syllable presentation in both modalities. Psychonomic Science, 1969, 17, 341-342.

Hagen, J. W., & Kingsley P. R. Labeling effects in short-term memory. Child Development, 1968, 39, 113-121.

Hagen, J. W., Meacham, J. A., & Mesibov, G. Verbal labeling, rehearsal and short-term memory. Cognitive Psychology, 1970, 1, 47-58.

Hansen, D. N. Short-term memory and presentation rates with young children. Psychonomic Science, 1965, 3, 252-254.

Horowitz, A. B. Effect of stimulus presentation modes on children's recall and clustering. Psychonomic Science, 1969, 14, 297-298.

Kagan, J., & Kogan, N. Individuality and cognitive performance. In P. Mussen (Ed.), Carmichael's Manual of Child Psychology, Vol. 1. New York: John Wiley, 1970.

Keely, K. Age and task effects in short-term memory of children. Perception and Psychophysics, 1971, 9, 480-482.

Keeney, T. J., Cannizzo, S. R., & Flavell, J. H. Spontaneous and induced verbal rehearsal in a recall task. Child Development, 1967, 38, 953-966.

Kingsley, P. R., & Hagen, J. W. Induced versus spontaneous rehearsal in short-term memory in nursery school children. Developmental Psychology, 1969, 1, 40-46.

Klein, R. E., Hale, G. A., Miller, L. K., & Stevenson, H. W. Children's paired associate learning of verbal and pictorial material. Psychonomic Science, 1967, 9, 203-204.

Koppennal, R. J., Krull, A., & Katz, H. Age, interference, and forgetting. Journal of Experimental Child Psychology, 1964, 1, 360-375.

Kossuth, G. L., Carroll, W. R., & Rogers, C. A. Free recall of words and objects. Developmental Psychology, 1971, 4, 460.

Kurtz, K. H., & Hovland, C. L. The effect of vocalization during observation of stimulus objects upon accuracy of recognition and recall. Journal of Experimental Psychology, 1953, 45, 157-164.

Langer, J. Theories of development. New York: Holt, Rinehart & Winston, 1969.

Maccoby, E. E. The development of stimulus selection. In J. P. Hill (Ed.), Minnesota Symposia on Child Psychology, Vol. 3. Minneapolis: University of Minnesota Press, 1969

Maccoby, E. E., & Hagen, J. W. Effects of distraction upon central vs. incidental recall: Developmental trends. Journal of Experimental Child Psychology, 1965, 2, 280-289.

Mackworth, J. F. The relation between the visual image and post-perceptual immediate memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 75-85.

Mackworth, J. Interference and decay in very short-term memory. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 300-308.

Margrain, S. A. Short-term memory as a function of input modality. Quarterly Journal of Experimental Psychology, 1967, 19, 109-114.

Milgram, N. A., & Furth, H. G. The effect of verbalization and conceptual grouping on recall in children at three age levels. American Psychologist, 1963, 18, 350.

Moely, B. E., Olson, F. A., Halwes, T. G., & Flavell, J. H. Production deficiency in young children's clustered recall. Developmental Psychology, 1969, 1, 26-34.

Morton, J. A functional model for memory. In D. A. Norman (Ed.), Models of Human Memory. New York: Academic Press, 1970.

Murdock, B. B., Jr. The criterion problem in short-term memory. Journal of Experimental Psychology, 1966, 72, 317-324. (a)

Murdock, B. B., Jr. Visual and auditory stores in short-term memory. Quarterly Journal of Experimental Psychology, 1966, 18, 206-211. (b)

Murdock, B. B., Jr. Serial order effects in short-term memory. Journal of Experimental Psychology Monograph Supplement, 1968, 76, 1-15.

Murdock, B. B., & Walker, K. D. Modality effects in free recall. Journal of Verbal Learning & Verbal Behavior, 1969, 8, 665-676.

Murray, D. J. Vocalisation-at-presentation and immediate recall, with varying presentation rates. Quarterly Journal of Psychology, 1965, 17, 47-56.

Newell, M. The effects of acoustic disruption on short-term memory. Psychonomic Science, 1968, 12, 61.

Neufeldt, A. H. Short-term memory in the mentally retarded: An application of the dichotic listening technique. Psychological Monographs, 1966, 80 (12, Whole No. 620).

Paivio, A. On the functional significance of imagery. Psychological Bulletin, 1970, 73, 6, 385-392.

Paivio, A., & Yuille, J. C. Word abstractness and meaningfulness, and paired-associate learning in children. Journal of Experimental Child Psychology, 1966, 4, 81-89.

Palermo, D. S. Verbal learning and memory. In H. W. Reese, & L. P. Lipsitt (Eds.), Experimental Child Psychology. New York: Academic Press, 1970.

Pepper, R. L., & Herman, L. M. Decay and interference effects in the short-term retention of a discrete motor act. Journal of Experimental Psychology Monograph Supplement, 1970, 83, (2, pt. 2).

Piaget, J. The construction of reality in the child. New York: Basic Books, 1954.

Piaget, J. On the development of memory and identity. Worcester, Mass.: The Barre Publishing Company, Clark University Press, 1968.

Posner, M. I. Characteristics of visual and kinesthetic memory codes. Journal of Experimental Psychology, 1967, 75, 103-107.

Posner, M. I., & Konick, A. E. On the role of interference in short-term retention. Journal of Experimental Psychology, 1966, 72, 221-231. (a)

Posner, M. I., & Konick, A. E. Short-term retention of visual and kinesthetic information. Organizational Behavior and Human Performance, 1966, 1, 71-86. (b)

Posner, M. I., & Rossman, E. Effects of size and location of informational transforms upon short-term retention. Journal of Experimental Psychology, 1965, 70, 496-505.

Reese, H. W. Verbal mediation as a function of age level. Psychological Bulletin, 1962, 59, 502-509.

Reese, H. W. Imagery and contexual meaning. Psychological Bulletin, 1970, 73, 404-414.

Rohwer, W. D. Images and pictures in children's learning: Research results and educational implications. Psychological Bulletin, 1970, 73, 393-403. (a)

Rohwer, W. D. Mental elaboration and proficient learning. In J. P. Hill (Ed.), Minnesota Symposia on Child Psychology. Vol. 4. Minneapolis: University of Minnesota Press, 1970. (b)

Rohwer, W. D., Jr., Lynch, S., Suzuki, N., & Levin, J. R. Verbal and pictorial facilitation of paired-associate learning. Journal of Experimental Child Psychology, 1967, 5, 294-302.

Rohwer, W. D., Jr., Levin, J. R., & Suzuki, N. Pictorial and verbal factors in the efficient learning of paired associates. Journal of Educational Psychology, 1967, 58, 278-284.

Ryan, S. M., Hegion, A. G., & Flavell, J. H. Nonverbal mnemonic mediation in preschool children. Child Development, 1970, 41, 539-550.

Sidman, M. Tactics of Scientific Research: Evaluating Experimental Data in Psychology. New York: Basic Books, 1960. Cited by Gollin, E. S. Developmental approach to learning and cognition. In L. P. Lipsitt & C. C. Spiker (Eds.), Advances in Child Development and Behavior. Vol. 2. New York: Academic Press, 1965.

Snedecor, G. W., & Cochran, W. G. Statistical Methods. (6th ed.) Ames, Iowa: The Iowa State University Press. 1967.

Sperling, G. A model for visual memory tasks. Human Factors, 1963, 5, 19-36.

Thorndike, E. L., & Lodge, I. The teacher's word book of 30,000 words. New York: Teacher's College, Columbia University, Bureau of Publications, 1944.

Underwood, B. J. Interference and forgetting. Psychological Review, 1957, 64, 49-60.

Wickelgren, W. A. Short-term recognition memory for single letters and phonemic similarity of retroactive interference. Quarterly Journal of Experimental Psychology, 1966, 18, 55-62. (a)

Wickelgren, W. A. Numerical relations, similarity, and short-term recognition memory for pairs of digits. British Journal of Psychology, 1966, 57, 263-274. (b)

William, H. L., Beaver, W. S., Spence, M. T., & Rundell, O. H. Digital and kinesthetic memory with interpolated information processing. Journal of Experimental Psychology, 1969, 80, 530-536.

Acknowledgments

It gives me great pleasure to acknowledge with thanks the valuable help and guidance given by Dr. Wayne H. Bartz in the planning and conduct of this research. His willingness to share his time and ideas, and his respect for the student are highly commendable. Working with him has been an immensely rewarding experience.

I wish to express my deepest appreciation to Dr. Damaris Pease, Cochairman of my committee, for her kind counsel in planning my program, and for the many ways by which she has helped make this program meaningful to me.

I greatly appreciate the generous help extended by Dean Helen Hilton at every stage of the program. I also wish to thank Dean Hilton for extending financial help from the Home Economics Research Institute of the College of Home Economics for conducting research and computer programming.

I owe a special debt of gratitude to Dr. Don Charles. I am indebted to him for his generous and timely help, his friendly counsel and constant encouragement.

Having Dr. Leroy Wolins on my committee has been my proud privilege. I acknowledge his help in planning the research design and in statistical analysis of the data with great appreciation.

Appreciation is extended to Dr. Sam Clark for serving as a member of my committee and to Mrs. Daniel Wahab for her tremendous help in the conduct of the experiment.

My thanks are also due to Mr. V. L. Schwenk, Superintendent, Gilbert School District, and to Mr. Kiser, Superintendent Ames School District for providing the subject sample. I greatly appreciate the generous cooperation extended by the principals, teachers, and children of both Gilbert Elementary School, Gilbert and Edwards School, Ames, in the conduct of the study.

To the members of my family, especially my parents and brothers who have been a constant source of moral support, I owe an infinite debt of gratitude.

This program of study at Iowa State University was made possible by the award received from the Ford Foundation and the M. S. University of Baroda in cooperation with Iowa State University under a grant from the Ford Foundation.

Appendix A:

Instructions to Subjects

Instructions to Subjects

At the beginning of the first session the third- and sixth-grade children were told "I want to study how boys and girls of your age remember. You can help me in this by paying good attention and remembering as much as you can of what I show or tell you." The kindergarten children were told it was a memory game. The specific instructions differed with the mode of presentation.

Verbal mode of presentation. "This time I want to see how well you can remember some words. I will call out some words, one at a time, and as I call out each word I will point to one card on the table, starting from here (E indicating the first card to the left of S) and going down the line (indicating the row of blank cards from Ss left to right). You listen to the words carefully and watch which card I point to. Later I will call out one word and ask you to show me which card it went with. If you don't get it right the first time you get one more chance. Now let us practice and see how this goes." One practice trial was given with immediate recall. For the practice trial with interpolated activity, after the presentation of the five words, S was told "now let us do this for awhile" and the interpolated activity (verbal, visual or motor) was introduced.

Visual mode of presentation. The preliminary instructions were the same as in the verbal condition. The S was then told "This time you have to remember some pictures. I will show you these pictures one at a time and then place them face down on the table all in a row." (E demonstrated the placement of the cards along with the instructions.)

"Now you carefully watch each picture I show and see where I put it. Later I will show you a picture just like one of those pictures and you have to show me where it is in the row here. If you don't get it right the first time you get one more chance. Now let us practice and see how it goes." The first practice trial was with immediate recall. For the practice trial with interpolated activity, the instructions and procedure were the same as in the verbal condition.

Motor mode of presentation. The initial instructions were the same as in the verbal and visual condition. The Ss were then told "This time I will put up these cards one at a time (E mounted a geometrical design cut out on cardboard, on a wooden block). You take the pencil and trace it like this (E demonstrated the tracing). You have to remember that this design goes with this card here (E indicated the first blank card to S's left). Now I will take that (the card that was just traced) out and put up another. Trace this. Now remember, this design goes with...(E indicated the second blank card on the table). So we go down the line. After all the five designs were traced, E placed the cue card and said 'Trace this.' Now show me which card this design went with." S was given a second choice when necessary.

All instructions were carried out along with demonstration with the materials. None of the Ss had any difficulty in following the instructions. For every correct choice made S was praised with "very good, that is right"; if wrong, S was told "no that's not right, choose once more". S was praised for the correct second choice also. When a

wrong choice was made, E indicated the card in the right position and said "see you were pretty close" or "almost got it, didn't you?"

Appendix B:

Summary Analysis of Variance of Total Recall Scores in Relation to Age, Sex, Mode of Presentation and Interference - Study I & Study II

TABLE 8

Analysis of Variance-Recall Scores (Study I)

Source	d.f.	M.S.	F
Age (A)	2	1151.0703	53.38***
Sex (S)	1	0.0045	-
A x S	2	12.6585	-
Error (1)	36	21.56	
Mode (M)	2	3.6906	-
A x M	4	11.2656	2.09
S x M	2	.8604	-
A x S x M	4	2.8263	-
Treatment (T)[a]	2	21.0384	3.95*
A x T	4	10.7415	1.99
S x T	2	6.0234	1.11
A x S x T	4	3.8256	-
Error (2)	72	5.3796	
Interference (I)	1	282.2400	52.85***
A x I	2	4.7907	-
S x I	1	0.0711	-
A x S x I	2	1.2303	-
Error (3)	36	5.34	
M x I	2	18.2187	2.89
A x M x I	4	2.7558	-
S x M x I	2	6.3753	1.01
A x S x M x I	4	.7338	-
M x I x T	2	36.5085	5.80**
A x M x I x T	4	7.0460	1.12
S x M x I x T	2	4.6728	-
A x S x M x I x T	4	0.4401	-
Error (4)	72	6.29	

[a] 'Treatment' refers to type of interference.

*p .05.

**p .01.

***p .001.

TABLE 9

Analysis of Variance-Recall Scores (Study II)

Source	d.f.	M.S.	F
Age (A)	2	709.0801	42.36***
Sex (S)	1	12.8401	-
A x S	2	29.5277	1.76
Error (1)	6	16.7430	
Mode (M)	2	18.3958	1.26
A x M	4	9.7917	-
S x M	2	0.4653	-
A x S x M	4	6.4028	-
Error (2)	12	14.5972	
Interference (I)	3	62.2846	9.03**
A x I	6	3.0834	-
S x I	3	6.6737	-
A x S x I	6	5.3611	-
Error (3)	18	6.6689	
M x I	6	19.4792	2.55*
A x M x I	12	4.4444	-
S x M x I	6	5.2153	-
A x S x M x I	12	10.7778	1.41
Error (4)	36	7.6341	

*p .05.

**p .01.

***p .001.

Appendix C:

Summary Analysis of Variance of Total Recall Scores in Relation to Age, Sex, Mode of Presentation and Interference - Study I: Experimental Groups I, II & III

TABLE 10

Analysis of Variance - Recall Scores Study I: Group I

Source	d.f.	M.S.	F
Age (A)	2	507.3699	25.17***
Sex (S)	1	78.3702	3.88
A x S	2	9.5926	-
Error (1)	12	20.1481	
Mode (M)	2	22.6759	3.91*
A x M	4	4.2870	-
S x M	2	0.4537	-
A x S X M	4	5.1759	-
Error (2)	24	5.8009	
Interference (I)	1	92.5921	9.88**
A x I	2	16.9259	1.81
S x I	1	0.0370	-
A x S x I	2	3.3704	-
Error (3)	12	9.3704	
M x I	2	4.8982	1.58
A x M x I	4	2.8148	-
S x M x I	2	2.5648	-
A x S x M x I	4	1.6481	-
Error (4)	24	3.1067	

*p .05.

**p .01.

***p .001.

TABLE 11

Analysis of Variance - Recall Scores Study I: Group II

Source	d.f.	M.S.	F
Age (A)	2	397.8979	17.76***
Sex (S)	1	57.7870	2.58
A x S	2	14.1204	-
Error (1)	12	22.3981	
Mode (M)	2	4.9259	1.00
A x M	4	0.2176	-
S x M	2	5.8148	1.18
A x S x M	4	2.6898	-
Error (2)	24	4.9120	
Interference (I)	1	2.6759	1.04
A x I	2	0.8981	-
S x I	1	0.0093	-
A x S x I	2	1.7871	-
Error (3)	12	2.5648	
M x I	2	18.4814	1.96
A x M x I	4	1.4953	-
S x M x I	2	6.4814	-
A x S x M x I	4	2.3009	-
Error (4)	24	9.4399	

***p .001.

TABLE 12

Analysis of Variance - Recall Scores Study I: Group III

Source	d.f.	M.S.	F
Age (A)	2	264.4534	12.27**
Sex (S)	1	1.5648	-
A x S	2	3.3982	-
Error (1)	12	21.5370	
Mode (M)	2	7.1204	1.31**
A x M	4	23.1620	4.26
S x M	2	1.5648	-
A x S x M	4	4.1898	-
Error (2)	24	5.4259	
Interference (I)	1	444.0833	109.11***
A x I	2	0.0027	-
S x I	1	0.7499	-
A x S x I	2	3.5278	-
Error (3)	12	4.0741	
M x I	2	93.0833	14.72***
A x M x I	4	8.5694	1.36
S x M x I	2	6.0834	-
A x S x M x I	4	6.3194	-
Error (4)	24	6.3242	

**p .01.

***p .001.

Appendix D:

Abstract Drawings Used in the Visual Memory Task